Black cola drinks, oral health and general health: AN EVIDENCE-BASED APPROACH

Part 1: Oral health issues

Recent advertising material from companies which manufacture black cola soft drinks should be of concern to all oral health professionals.

Some of the advertising material on the Coca Cola website makes interesting reading, to say the least. *"MYTH: Drinking 'Coca-Cola' will rot your teeth. Drinks like 'Coca-Cola' are swallowed quite quickly and the saliva in your mouth washes away the sugar and acid."* [1] This follows on from a public letter from the Managing Director of Coca Cola South Pacific, Mr Gareth Edgecombe, which reads "You may have seen us in the headlines again this week with Coke being blamed for causing tooth decay and obesity. Our new "myth busting" ad campaign is aimed at dispelling the myths and misinformation around Coke".

There appears to be a singular disconnect from the messages portrayed in the mass media and the experience of clinical practice. (Fig. 1) In these days of evidence-based practice in health care, what does the recent evidence from the literature actually say?

Fig. 1. The positive portrayal of black cola drinks in the media (left) is vastly different from the reality often encountered in clinical practice (right – a patient who has been consuming 2.5 litres per day for several years).

BLACK COLA DRINKS AND DENTAL CARIES

The high cariogenicity of black cola drinks is recognized by all dental professionals as well as dieticians, and follows on from the accepted role of refined carbohydrates, particularly sucrose, in the caries process.[3] When sucrose intake exceeds 15 to 20 kilograms per person per year, such intake is directly associated with increasing caries prevalence, particularly when sucrose is consumed between meals. Indeed, current dental health education for the control of dental supports dietary restriction of sucrose to prevent caries.[4] Consumption of high-carbohydrate liquids is a risk factor for excessive caloric intake and obesity.[5] With a sucrose content typically in the range of 10-12 per cent, a 375mL can contains in excess of 40 grams of sucrose, thus one can of sugared soft drink per day for one year will in itself account for 15 kilograms of sucrose per year.

Concerns regarding dental and general health issues have seen bans placed on soft drinks in schools in various jurisdictions, including Queensland. Similar nutritional concerns regarding soft drink consumption in schools have been raised internationally. For example, the American Academy of Pediatrics has highlighted the three major health problems associated with a high intake of sweetened drinks as (1) obesity attributable to additional calories in the diet; (2) displacement of milk consumption, resulting in calcium deficiency with an attendant risk of osteoporosis and fractures; and (3) dental caries and enamel erosion.[6] Their advice to restrict the sale of soft drinks to safeguard against health problems as a result of over-consumption is in line with current public health and dietetic advice in Australia.

Associations between DMFS scores and soft drink consumption in persons aged 25 and above have been seen in recent large cohort studies in the USA involving more than 30,000 subjects. These show a dose response between daily servings of sugared soft drinks in the diet, and DMFS scores in the same individuals.[7] The interpretation of this finding is self evident – a higher sucrose intake has increased dental caries activity.

It is concerning that some soft drink manufacturers continue to promote the view that their products are readily washed out from the oral cavity by saliva, and therefore do not contribute to dental caries. This view has been regarded as outdated since the early 1980's. The seminal work by Ismail *et al*. in the 1980's on the cariogenicity of soft drinks in more than 3,100 children and young adults demonstrated an association between the frequencies of at- and between-meal consumption of soft drinks and high DMFT scores. These associations remained even after accounting for the reported concurrent consumption of other sugary foods and other confounding variables. The results of this study, which were published in 1984, debunk the view that only adhesive sugary foods are cariogenic. In fact, the authors of this landmark study cautioned dental professionals that in their approach to dental health education, they must not imply that sugary solutions are less cariogenic than sticky snacks, arguing

that there may be no difference in their effective cariogenicity in a modern lifestyle.

The cariogenicity of black cola drinks is, of course, ably demonstrated in animal caries models, which are used widely to quantify the cariogenicity of different foodstuffs. Such animal models also demonstrate that cola drinks cause dental erosion as well as dental caries, leading to "devastation of the dentition".[9] Given that black cola drinks contain 10-12 per cent sucrose; a direct comparison of them to 10 per cent sucrose in water is rather informative. Such caries studies in animals show that, when matched for the same sucrose content, black cola drink is the much more cariogenic of the two liquids, a fact which is explained by the combination of sucrose with other ingredients in a low pH vehicle. Dramatic caries is seen in such animal models within two weeks of continuous use of Coca Cola ™.[9] (Fig. 2)

A high frequency of exposure to dietary acids will have ecological effects on the oral biofilm and can shift the supragingival oral flora toward aciduric microorganisms. As the intra-oral pH falls, the numbers and proportions of aciduric organisms such as Mutans streptococci and Lactobacilli increase, and the proportions of acid-sensitive species fall. The reduction in pH caused by the drink not only enhances the competitiveness of cariogenic organisms, but also inhibits the growth and metabolism of non-caries-associated species.[10]

ACIDS IN BLACK COLA DRINKS AND DENTAL EROSION

'Regular' black cola drinks contain orthophosphoric acid, which is labelled as 'food acid 338', while diet black cola drinks contain both orthophosphoric acid and citric acid (food acid 330). Lemon varieties of black cola drink contain orthophosphoric, citric and tartaric acid (food acid 334).[10]

It is well known that orthophosphoric acid will dissolve the protective pellicle layer deposited by saliva onto teeth, and will etch both enamel and dentine. This is aptly demonstrated in patients who swish black cola drinks for extended periods of time, and develop surface changes typical of acid etching. (Fig. 3)

Citric acid sequesters calcium ions from saliva, preventing remineralization, etches dentine, and causes dental erosion. The combination of these various acids gives black cola drinks a low pH. This is typically in the pH 2-3 range, depending on the drinks temperature and whether still gassed – since dissolution of carbon dioxide adds additional acid in the form of carbonic acid. More importantly, these various acids are effective buffers, giving the drinks high titratable acidity, and making their pH reducing effects in the mouth greater than the protective buffering actions of saliva. This explains why enamel and dentine hardness decrease after exposure to black cola softdrink, and erosion areas develop.[10]

There is an extensive literature on erosive effects of black cola drinks. Representative data for changes in enamel micro-hardness over hours (Fig. 4) and then days (Fig. 5), in the laboratory using enamel slabs confirm the often mentioned 'tooth in a glass of black cola soft drink' type of experiment.[11,12] The enamel softening action is not inhibited if the teeth are first coated in salivary pellicle, since this protective layer is rapidly proteolyzed by the orthophosphoric acid to then expose the underlying enamel surface. Also noteworthy is that the softening action of these drinks is the same on the enamel of both primary and permanent teeth. (Fig. 5)

The erosive effects relate to the various acids in the drink, rather than to caffeine or other components.[13] Soft drink pH, i.e., initial pH has been shown to be a causative factor in dental erosion,

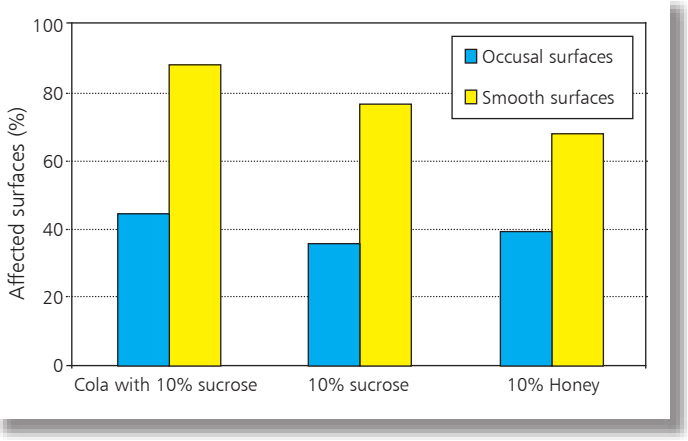

Fig. 2. Data from animal caries assessments of a black cola drink with 10 per cent sucrose, water with 10 per cent sucrose, and water with 10 per cent honey. The vertical scale indicates the proportion of available occlusal surfaces (blue) or smooth surfaces (yellow) affected by dental caries after two weeks of continuous dietary intake. Note the higher cariogenicity of the cola drink. Based on data from Reference 7.

Fig. 3. Surface changes of labial enamel (etching and erosion) in a teenage patient who swishes black cola soft drinks around his mouth during the day.

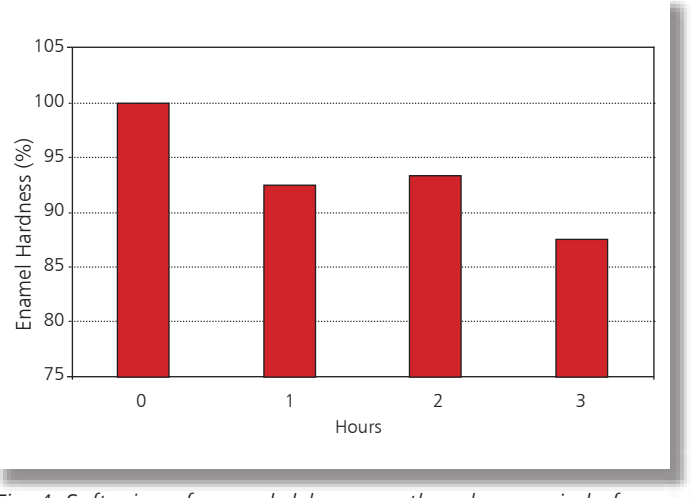

Fig. 4. Softening of enamel slabs over a three hour period of exposure to black cola softdrink. The vertical scale represents the hardness expressed as a percentage of the baseline value. Based on data from Reference 11.

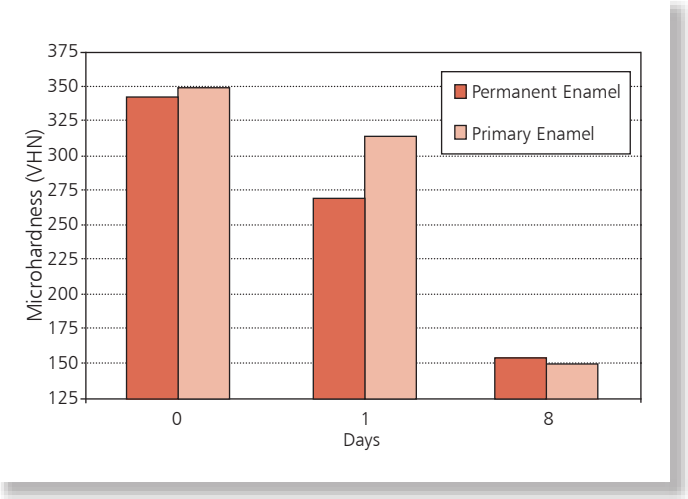

Fig. 5. Softening of enamel slabs over an eight day period of intermittent exposure to black cola softdrink alternated with artificial saliva. The vertical scale represents the Vicker's hardness. Changes in both primary and permanent enamel hardness evident after one day worsen over the following week. Based on data from Reference 12.

but it is not necessarily the primary initiating factor – this is where titratable acidity or buffering capacity becomes of greater importance. This ability of the soft drink to resist pH changes brought about by salivary buffering systems is normally assessed in the laboratory by measuring the amount of 0.1 M sodium hydroxide necessary for titration of the drink to pH levels of 5.0, 6.0, 7.0, and 8.0. Such assessments show that Coca-Cola™ 'Classic' has a lower pH and a higher titratable acidity than Diet Coke™.[14]

Of particular concern, once mineral loss has occurred, even extended exposure to saliva appears unable to completely repair this. As an example of this, in the study of van Eygen *et al.*, 15 blocks of human enamel were immersed in Coca-Cola™ over seven days at different frequencies: one, two or three times per day for 20 minutes each, with each immersion followed by a one hour period with the block immersed in artificial saliva. Specimens in a fourth group were immersed for one minute in the soft drink followed by three minutes in artificial saliva, and this cycle repeated for 20 minutes to better simulate drinking habits. Control specimens remained in physiological serum at room temperature. Exposure to artificial saliva was unable to protect enamel from the erosive softening actions of the drink, regardless of the experimental protocol used. This raises concerns over even brief periods of intake to such drinks.

It must also be remembered that similar concerns of surface softening apply to dental restorative materials. As a typical example of this, in a recent study, specimens of dental materials were alternately immersed for five seconds in black cola drink and then in artificial saliva, for a total of 10 cycles. Baseline and post-immersion hardness tests showed that black cola soft drink significantly reduced surface hardness of micro filled composite and resin modified glass ionomer, as well as enamel and dentine.[16]

CAFFEINE

Caffeine is the most widely used addictive substance in the world, and its inclusion into soft drinks is problematic since this will promote regular intake of such drinks to sustain caffeine levels at the 'maintenance' intake level of 70 mg/day in an average size adult.[17]

The reasons why caffeine is a popular material in the modern diet are well known. It increases wakefulness and mental alertness, giving a faster and clearer flow of thought. It has a stimulant action on the vasomotor and respiratory centres of the brain, improving physical performance by increasing cardiac contractility and output, dilating the coronary arteries, and relaxing bronchial smooth muscle.[18]

Caffeine also increases secretion of gastric acid (worsening any underlying problems of gastric reflux), and increases urine output, giving a diuresis which can impact negatively on fluid balance and thus lower resting salivary flow, pH and buffer capacity, with consequential effects on oral health.[10]

Because chronic high intake of caffeine through black cola drinks and other sources is associated with habituation and tolerance, sudden discontinuation of these drinks may produce a withdrawal syndrome. This needs to be borne in mind when advising patients to reduce their daily intake, which should be done gradually.

Some recent advertising material tries to downplay the significance of caffeine in black cola drinks, for example: *"MYTH: 'Coca-Cola' is packed with caffeine. The caffeine content in most soft drinks such as 'Coca-Cola', 'Diet Coca-Cola' and 'Coca-Cola Zero' is about one third the level found in the same amount of coffee and one half of the amount of caffeine that's in most teas. Caffeine is added to contribute to the complex flavour of some soft drinks and has been used for this purpose for more than 100 years"*.[1] The comparison here is rather misleading, since the recognized levels of caffeine are 70 mg per 300 mL cup of instant coffee; 35 mg per 300 mL cup of tea; and 35-47 mg per 375 mL can of black cola drink – figures which give a rather different impression of the relativity between these beverages.[10] Official figures for caffeine content from the United States Department of Nutritional Services are shown in Table 1.

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REFERENCES

References supplied with this article are available on request by contacting newsbull@ada.org.au

Table 1. Typical caffeine content data for beverages, per 375 mL can

Coca Cola Classic (375 mL can)	37 mg
Diet Coke (375 mL can)	47 mg
Coke Zero (375 mL can)	35 mg
Pepsi Cola (375 mL can)	38 mg
Diet Pepsi (375 mL can)	36 mg
Regular instant coffee (cup)	47-68 mg
Drip filter coffee (cup)	106-164 mg
Black tea, 1 minute brew (cup)	21-33 mg

These official United States data are consistent with recently published analytical studies, such as Reference 38. For a useful history of the famous 1911 investigation of the behavioral effects of caffeine (known as the Chattanooga trial), see Reference 39. This psycho-pharmacological research was necessitated by a United States Federal Government lawsuit against the Coca-Cola Company for marketing a beverage with a deleterious ingredient, namely, caffeine.